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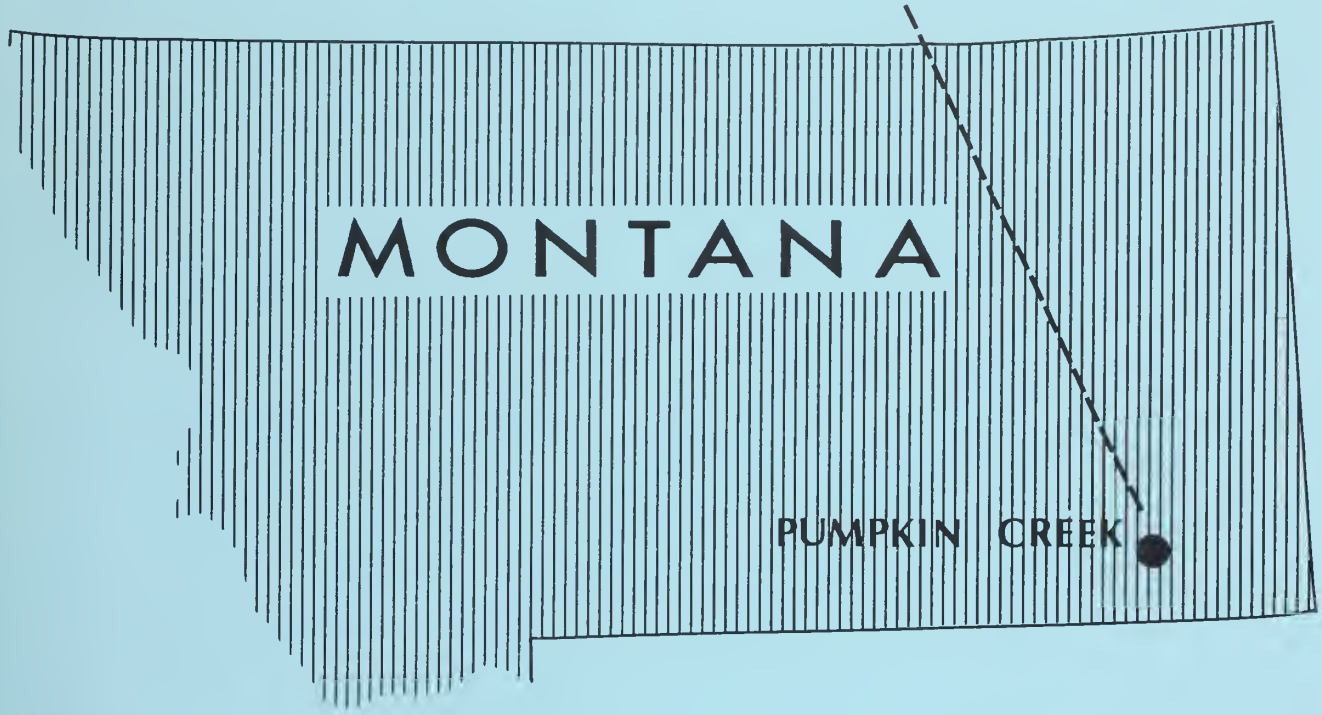
Pumpkin Creek Study Area Report



RESOURCE & POTENTIAL RECLAMATION EVALUATION

SUMMARY

Pumpkin Creek Study Area Report
Published February 1982

The Federal Coal Management Program has been designed as an interagency cooperative effort to meet national energy objectives.

Pumpkin Creek Study Area Report was prepared through the efforts of the U.S. Department of the Interior, principally the Bureau of Land Management, Geological Survey, and Bureau of Reclamation.* The study effort began in 1978 and was concluded in 1982 with the publication of this report.

The area described in this report has been tentatively determined to be a potential Federal coal development area. The purpose of this report is to provide information on the area's reclamation potential should coal development occur. This report will assist managers in making final Federal coal leasing decisions.

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*In May of 1981, the Secretary of the Interior approved changing the Water and Power Resources Service back to its former name, the Bureau of Reclamation. All references in this publication to the Water and Power Resources Service should be considered synonomous with the Bureau of Reclamation.

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16. Abstract The purpose of this investigation was to collect baseline data for establishing reclamation objectives and lease stipulations. The report includes data on climate, physiography, geology, coal resources, overburden, hydrology, and greenhouse tests. The study area, located in the northern part of the Powder River Basin, lies within the unglaciated portion of the Great Plains Physiographic Province. Bedrock exposed in the area is the Tongue River Member of the Paleocene Fort Union Formation. Three coalbeds were evaluated - , Sawyer, and Mackin-Walker. The coal has an apparent rank of Lignite A. Most soils in the study area should yield about 6 to 12 inches of topsoil which is nonsaline, nonsodic, and permeable. Available subsoil materials appear fair to poor in quality. Only 3 percent of the bedrock samples from 11 USBR drill holes were rated suitable for use as supplemental plant media. Streamflow in the study area occurs in response to spring and rainstorm runoff. Shallow ground water occurs in permeable units of the Tongue River Member. Both surface and ground water quality is variable. Surface mining will not significantly affect streamflow outside the study area; however, mining could remove 12 perennial and 25 ephemeral reservoirs. Dissolved solids and sediment concentrations could increase in reservoirs downstream from mine strips. Ground water problems are expected to be minimal. One well could be dewatered and six wells and three springs could be removed by surface mining. Based on the resource data in this report, it appears that restoration of disturbed lands in this study area to their premining uses, though possible, would be more difficult than in other areas in southeastern Montana previously studied under the EMRIA program.

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION OF PUMPKIN CREEK STUDY AREA PUMPKIN CREEK COALFIELD POWDER RIVER COUNTY, MONTANA

INTRODUCTION

Recent energy shortages have forced our society to seek new domestic sources. Attention has focused on the immense quantities of low sulfur coal that lie within the Rocky Mountain and Northern Great Plains regions. It is the responsibility of the Department of the Interior and, principally, the Bureau of Land Management to assist in meeting these energy demands and, at the same time, provide sound reclamation guidelines so that the disturbed lands are restored to an acceptable condition.

PURPOSE

The purpose of this report is to provide information for establishing reclamation objectives and lease requirements. Detailed data is given on geology, coal resources, overburden (soil and bedrock), greenhouse investigations, and hydrology. Less detailed information is provided on climate and physiography.

LOCATION

The Pumpkin Creek Study Area is located in southeastern Montana (Powder River County), approximately 15 miles northwest of the town of Broadus. Plate 1 shows the general location. The study area includes 10,880 acres in the following complete sections: T. 2 S., R. 49 E., sections 14, 22, 24, 26, 28, 34, and T. 3 S., R. 49 E., sections 2, 4, 8, 14, 18, 20, 22, 26, 28, 30, and 32, as shown on Plate 2. The majority of surface ownership in the study area is private; the remainder is Federal, as shown on Plate 3. All coal in the study area is federally owned, as shown on Plate 4.

PRESENT LAND USES

The Pumpkin Creek Study Area is used primarily for livestock grazing. Limited dryland and irrigated farming occurs on the private surface. In the northern part of the study area, scattered ponderosa pine and juniper occur, but there is no known commercial timber production. Portions of the study area provide superior habitat for wildlife with a high species diversity.

POSTMINING LAND USES

Postmine land use is anticipated to be livestock grazing, with limited dryland or irrigated farming.

OBJECTIVE OF RECLAMATION

Montana law presently requires the coal mine operator to restore all disturbed areas, "in a timely manner, either to conditions capable of supporting the uses they were capable of supporting before any mining or to conditions capable of supporting approved alternative land uses. Alternative land uses may be approved by the Department of State Lands after consultation with the landowner or the land-management agency having jurisdiction over the lands . . ." (Rule XVI, 5(c) pursuant to "The Montana Strip and Underground Mine Reclamation Act" - Montana Permanent Program).

Unless an alternative postmining land use is desired by the landowner(s) and approved by the Montana Department of State Lands, the main objective of reclamation in the Pumpkin Creek Study Area would be to establish a diverse vegetative cover with an interspersion of vegetative types over the reclaimed land capable of supporting livestock and wildlife. The integrity of the visual resource should be maintained.

CLIMATE

The Pumpkin Creek Study Area has a continental-type semiarid climate characterized by cold winters, warm summers, and large variations in seasonal precipitation. Data recorded between 1937 and 1961 at Broadus, Montana (approximately 15 miles southeast of the study area) were used to evaluate precipitation, temperature, and related climatic factors for the study area.

The average annual precipitation for this study area is about 13.8 inches, with approximately 73 percent of this amount occurring during the period of April through September. May and June are the wettest months, receiving 39 percent of the annual precipitation. Snowfall is most common between October and late April and may comprise as much as 32 percent of the annual precipitation.

Temperature extremes of 108 degrees F and -42 degrees F have been recorded in this area. The average annual temperature is 45.1 degrees F. The growing season for this area averages 100 to 128 days when the temperature exceeds 32 degrees F (frost-free period) and 144 days when the temperature is above 28 degrees F (growing season for hardy crops). Growth of native range plants is rapid during May and June. However, by mid-July the available soil moisture is usually depleted and the plants mature or become dormant.

Thunderstorms and occasional destructive hailstorms occur most frequently in this area during July and August. Damage to range plants from these storms is usually minimal. However, the more intense storms may result in severe soil erosion, especially in steeply sloping and sparsely vegetated areas.

Considerable sunshine can be expected in all seasons, except for the rainy period during May and June and occasional cloudy periods in November and December.

Climate may be a limiting factor for revegetation of disturbed land in the Pumpkin Creek Study Area. Generally, soil moisture is relatively high during the early part of the growing season and plant growth is rapid. Plants seeded in the fall or early spring should be established before the available soil moisture is depleted in about mid-July.

Climatic factors that may adversely affect revegetation efforts in this study area include: (1) below normal or uneven distribution of precipitation, especially during the growing season, (2) severe thunderstorms and/or strong winds that cause erosion, (3) late spring freezes, and (4) depletion of soil moisture by wind.

More detailed investigations will be necessary prior to mining to more accurately determine probabilities of occurrence of these factors. This data can then be used to predict best possible seeding times for revegetation.

PHYSIOGRAPHY

The Pumpkin Creek Study Area is located in the northern part of the Powder River Basin in Powder River County, Montana. This basin lies within the unglaciated Missouri Plateau section of the Great Plains Physiographic Province. Pumpkin Creek, a tributary of the Tongue River, forms the western border of the study area. The town of Broadus, Montana, is located about 15 miles southeast of the study area.

The relief in this study area is about 350 feet, with elevations ranging from 3700 feet in the south-central portion of the area to 3350 feet in Pumpkin Creek Valley in the northwestern corner of the area. Surface gradients are variable, ranging from 0 to 2 percent in Pumpkin Creek Valley to greater than 35 percent in semibadlands terrain in the uplands.

Drainage of the study area is accomplished through an extensive system of branching natural drains (dendritic pattern). The general flow of drainage is northward to the Yellowstone River via Pumpkin Creek and the Tongue River.

GEOLOGY

The Pumpkin Creek Study Area is in the northern part of the Powder River Basin. This deep sedimentary basin is about 225 miles long and 90 miles wide. It extends from the Yellowstone River in Montana to the North Platte River in Wyoming and from the Black Hills of South Dakota to the Bighorn Mountains of Wyoming.

Bedrock exposed in the study area is the Tongue River Member of the Fort Union Formation of Paleocene Age. Unconsolidated alluvial and terrace deposits of Holocene and Pleistocene Age mantle the valley floors and benches along the major drainages.

Engineering property tests performed on bedrock materials similar to those in the Pumpkin Creek Study Area revealed that shear strengths are low. Slides can develop adjacent to high walls in surface mines, and saturated

alluvial deposits and uncemented siltstones and fine-grained sandstone will readily erode and flow into excavations.

Excavation slopes will vary between minesites and will be dependent on exposure time, moisture conditions, material types, and depth of cut.

After disturbance, an increase of about 25 percent will occur in the volume of the overburden. Some areas of the surface will actually be higher in elevation after mining. Settlement will then occur for several years after reclamation until the materials reach a stable condition.

Three types of instability are common on reclaimed coal-mined areas in the Northern Great Plains. They are: (1) areawide settling, (2) localized collapse, and (3) piping. Each form of instability is affected by certain variables in the postmining landscape. These variables include the physical and chemical characteristics of the overburden, the method and equipment used in stripping and contouring operations, and the season when these activities occur. One or more of these types of landscape instabilities may occur on reclaimed land in the Pumpkin Creek Study Area.

Weathering tests conducted on bedrock core samples from the study area showed that shale samples break down more readily than either siltstones or sandstones, but handling these clay-rich materials may be difficult because of their plasticity.

A study of the seismic history of the region indicates that minor damage could result to structures from earthquake shocks.

COAL RESOURCES

The Pumpkin Creek site covers an area of about 94 square miles. It is located mainly in the southwestern part of the Coalwood Coalfield on the slightly westward dipping beds of the Tongue River Member of the Paleocene Fort Union Formation.

Three coalbeds: A, Sawyer, and Mackin-Walker, were evaluated by 32 drill holes. Coal resources - measured, indicated, and inferred - within the site and in beds more than 5 feet thick are 191,660,000 short tons in the A bed, 1,356,950,000 short tons in the Sawyer bed, and 34,400,000 short tons in the Mackin-Walker bed.

The coal has an apparent rank of lignite A as shown by the analyses of 17 core samples. The average Btu value of 15 core samples of the Sawyer from the site on the as-received basis is 6,970; average ash content is 6.8 percent; and average sulfur content is 0.4 percent. The Mackin-Walker has a Btu value of 7,220, an ash content of 6.9 percent, and a sulfur content of 1.0 percent.

A comparison of the analyses of samples from the Sawyer Coalbed with other analyses of Powder River region coal samples shows that moisture, hydrogen, and oxygen contents are significantly higher, and volatile

matter, fixed carbon, carbon, nitrogen, and total sulfur contents and heat of combustion are significantly lower in the Sawyer bed samples. A statistical comparison of the elemental compositions of the two sample groups shows that the Sawyer bed has significantly higher contents of B, Ba, Mn, Nb, U, Y, and Yb and significantly lower contents of Be, Co, Cr, Cu, Ni, Pb, Sc, Se, and Th.

The sample of the lower split of the Sawyer bed (bed A) in drill hole PWW8 has a relatively high sulfur content of 1.7 percent, and presumably would not be mined with the rest of the Sawyer.

OVERBURDEN - SOIL AND BEDROCK

PRINCIPAL SOIL BODIES

Soils of the Pumpkin Creek Study Area can be grouped into three major categories based on their parent material and landform position. These are: (1) residual soils developing over weathered shale or sandstone which occupy ridges, buttes, and gentle to steep sideslopes, (2) transported (alluvial/colluvial) soils forming over mixed deposits of soil material and rock fragments which occur on fans, footslopes, and in swales, and (3) alluvial valley floor soils developing over deep water-lain deposits on nearly level bottomlands adjacent to major tributary drainages. The residual soils occur over approximately 78 percent of the study area; the transported soils occupy about 17 percent of the study area; and the alluvial valley floor soils comprise the remaining 5 percent.

The residual soils have developed primarily from interbedded shale and sandstone of the Fort Union Formation (Tongue River Member). The solum (A and B horizons) of these soils is usually less than 20 inches in depth. Soil textures are mostly medium to moderately fine throughout the profiles. These soils are generally calcareous and slightly to moderately saline. Locally, they are also sodic.

The transported (alluvial/colluvial) soils have developed over loamy deposits which have accumulated through soil creep, slides, and local wash. Typically, these soils are moderately deep to deep over weathered sandstone or shale. Textures range from medium to fine depending on the nature of the deposits. The A and upper B horizons of most of these soils are slightly calcareous, whereas the lower B and upper C horizons are strongly calcareous. Most of these soils are slightly to moderately saline with the concentration of soluble salts typically reaching a maximum between 60 and 84 inches in depth. Moderately high to high levels of exchangeable sodium were found in some profiles, primarily in the subsurface (B and/or C) horizons.

The alluvial valley floor soils have developed over deep, loamy alluvium derived primarily from shale and sandstone. These soils are deep. Textures range from medium to fine, with interspersed coarse lenses being common. Generally, the A and B horizons are noncalcareous or slightly

calcareous. The C horizons are strongly calcareous. These soils are typically nonsaline to a depth of 24 to 36 inches. Below this, they are often slightly to moderately saline. Most of these soils are nonsodic; however, small areas of sodic alluvial valley floor soils occur locally in this study area, most likely associated with saline seeps.

LAND SUITABILITY SURVEY

A semidetailed land suitability survey of the Pumpkin Creek Study Area was made to evaluate and characterize the overburden (soil/bedrock to a depth of 10 feet) as a source of material for resurfacing and revegetating the area if it is surface-mined. This survey provides data on the quantity, quality, and ease of stripping and stockpiling the usable material. Basic data on the physical and chemical properties of the soils and bedrock are also provided by this survey.

Four land classes: 1, 2, 3, and 6 were established to group land of equal suitability for the specific use of revegetation. Class 1 lands provide the most desirable and plentiful source of easily stripped revegetative material. Land in this class generally has surplus suitable material that can be utilized in deficient areas. Class 2 lands contain an adequate supply of resurfacing material to revegetate the immediate area; however, this material is slightly less desirable in quality or somewhat more difficult to strip and stockpile than the material on Class 1 lands. Class 3 lands are similar to those in Class 2, except the deficiencies are more pronounced or a combination of deficiencies exists. Though they are marginally suitable, Class 3 lands can generally meet the plant media requirements for revegetation. Class 6 lands lack adequate quantities of suitable material to meet the needs for revegetation. If these lands are disturbed by surface mining, it will be necessary to borrow material from Class 1 or 2 lands or modify the material available for revegetation through leaching, chemical amendments, etc.

The results of the land suitability survey of the Pumpkin Creek Study Area expressed as a percentage of the area are as follows: Class 1 - 14.1, Class 2 - 24.4, Class 3 - 26.0, and Class 6 - 35.5.

OVERBURDEN SUITABILITY FOR REVEGETATION

Soil Mantle Suitability

Based on the field and laboratory data obtained from the land suitability survey, it appears that most of the residual, transported (alluvial/colluvial), and alluvial valley floor soils in this study area should yield about 6 to 12 inches of fair to good quality topsoiling material. This material, which generally includes the A and B horizons, is typically nonsaline, nonsodic, and moderately permeable.

Many of the soil profiles showed a moderate to strong increase in soluble salts, exchangeable sodium, and/or clay content between 12 and 18 inches in depth (C horizons). Therefore, a significant percentage of the available subsurface materials in this study area were classified as fair or poor for placement below the primary plant rooting zone in reconstructed profiles.

Bedrock Suitability

A systematic evaluation was made of the geologic core samples from Bureau of Reclamation drill holes 76-101 and 77-102 through 110 in order to determine suitability of the bedrock materials for use as plant media.

A complete set of laboratory data, including trace elements, provided the data base necessary to evaluate the bedrock materials. Although similar criteria were used for both the land suitability survey and bedrock suitability evaluation, different suitability classes were assigned to bedrock materials. These classes are "suitable," "limited suitability," and "unsuitable." The suitable class corresponds to Class 1 and the higher quality Class 2 materials; the limited suitability class includes the lower quality Class 2 and Class 3 materials; and the unsuitable class is equivalent to Class 6.

Overall, only 3 percent of the bedrock materials overlying the Sawyer/A coalbed in this study area were determined to be suitable for use as plant media, 14 percent were of limited suitability, and 83 percent were classified as unsuitable.

Excessive exchangeable sodium was the major limiting factor for the unsuitable materials. In 8 of the 10 drill holes, the highly sodic materials were overlain by 10 to 35 feet of nontoxic soil and bedrock. However, the remaining two drill holes were sodic to the surface. Placement of these materials at or near the surface in reconstructed profiles could seriously impair plant reestablishment. Therefore, these materials should be selectively placed well below the plant rooting zone. Other factors causing materials to be classified as unsuitable included high salinity, high clay percentage, and slow permeability.

The bedrock materials placed in either the suitable or limited suitability class could be utilized as subsurface material (below the primary plant rooting zone) on lands lacking an adequate supply of suitable material. However, separating and stockpiling these materials may be difficult.

Based on the physical and chemical limitations of the soils and bedrock materials described in this report, reconstruction of a profile suitable for successful plant reestablishment would be more difficult in the Pumpkin Creek Study Area than in other study areas previously investigated in southeastern Montana under the EMRIA Program.

SOIL INVENTORY

This section was incorporated into the main report in order to provide additional information on the soils occurring in the Pumpkin Creek Study Area. Most of the information was derived from soil survey data compiled by the Soil Conservation Service (USDA). The following data is included in the main report:

1. Soil Inventory Maps of the Pumpkin Creek Study Area showing the soil types/complexes/associations mapped by the Soil Conservation Service.

2. Soil series descriptions (National Cooperative Soil Survey).

3. Interpretive ratings for selected soil uses.

4. Engineering properties of the soils.

5. Erosion evaluations (BLM Form 7310-12) correlating with USBR Point Site Soil Profile Descriptions.

GREENHOUSE EVALUATION OF OVERBURDEN MATERIALS

The objectives of this study were twofold:

1. Characterize soil and bedrock materials as plant growth media in relation to reclamation and revegetation of surface-mined lands, and

2. Conduct soil and plant analyses of selected materials for identifying potential problems relating to toxicity and/or nutrient deficiencies that may limit plant growth.

Western wheatgrass was chosen as the primary test species since it is one of the most abundant native plant species in the western United States and will probably be used in many revegetation operations. Relative yields were calculated as a percentage based on the yield from each sample compared to the yield from a control soil.

Based on the results of soil and plant analyses and calculation of relative yields, the soil and bedrock samples were assigned ratings of suitable, questionable, or unsuitable for use as revegetative media.

The soil samples were rated 38 percent suitable, 34 percent questionable, and 28 percent unsuitable. The bedrock samples were rated 12 percent suitable, 20 percent questionable, and 68 percent unsuitable.

Salinity and/or sodicity problems appeared to be the major limiting factors for most of the materials classified as unsuitable. However, other factors which may have had a role in producing low relative yields included low levels of available phosphorus and low field capacities.

The greenhouse serves as an excellent tool for stratifying overburden materials as to their relative productivity. However, it must be noted that the percentage results listed above were obtained under controlled conditions. These results should not be used to predict revegetation potential under actual field conditions.

HYDROLOGY

SURFACE WATER

Streamflow in the Pumpkin Creek Study Area occurs in response to spring and rainstorm runoff. Flow estimated for an ephemeral drainage area of 1 mi^2 with 25-year frequency may be as high as 160 ft^3/s. Most of the runoff is intercepted by small reservoirs and hayfield irrigation before reaching Pumpkin and Mizpah Creeks.

Surface water quality is variable and depends on local conditions of surface runoff, evapotranspiration, and ground water. Water from selected perennial reservoirs is low in dissolved solids and nutrients, but high in pH. Average annual sediment yield to a selected stock reservoir was estimated to be about 0.06 acre-foot/mi^2. Water flow downstream from the study area is generally high in dissolved solids during base flow. Dilution of base flow is noticeable during periods of surface runoff.

GROUND WATER

Shallow water occurs in permeable units of the Tongue River Member of the Fort Union Formation. The potentiometric surface of the shallowest ground water generally conforms to area topography within or below the lowest strippable coal. Local perching of water is apparent above confining layers. Movement of water is controlled by topography, structure, and local recharge. Hydraulic conductivities determined from aquifer tests in coal and sandstone were less than 10 ft/d.

Ground water quality is also variable and may be attributed to circulation of recharge and heterogeneous minerology along flow paths in the Tongue River Member. Dissolved solids concentration is low to moderate. The most abundant cations are sodium, calcium, and magnesium. The most common anions are sulfate and bicarbonate.

EFFECT OF MINING ON WATER RESOURCES

Ground water problems associated with surface mining of the Sawyer "A" Coalbed are expected to be minimal. Mining of strippable coalbeds would partially drain saturated coal at a slow rate in the study area. One well could be dewatered and six wells and three springs could be removed by strip mining. The water quality in aquifer units below the mined coalbed will be unaffected if proper precautions are taken during closing of existing deep wells.

Surface mining would not significantly affect streamflow outside the study area. However, mining could remove 12 perennial and 25 ephemeral reservoirs. Dissolved solids and sediment concentrations could increase in reservoirs downstream from mine strips.

A hydrologic monitoring program would be needed to accurately describe potential water problems related to surface mining. Information from such a program could be optimized by consideration of each mining plan and its relation to the local hydrology.

VISUAL RESOURCE CONSIDERATIONS

According to Bureau of Land Management planning documents, the Pumpkin Creek Study Area has average scenic values with low visual exposure. The visual resource is not an important factor; therefore, it will not require special consideration in reclamation planning.

RECOMMENDATIONS FOR RECLAMATION

INTRODUCTION

If surface mining occurs in the Pumpkin Creek Study Area, the mine operator will be required to restore all disturbed areas "in a timely manner, either to conditions capable of supporting the uses they were capable of supporting before any mining or to conditions capable of supporting approved alternative land uses" /Rule XVI(5)(c) pursuant to the Montana Strip and Underground Mine Reclamation Act - Montana Permanent Program/.

Unless an alternative postmining land use is desired by the landowner(s) and approved by the Montana Department of State Lands, the main objective of reclamation in the Pumpkin Creek Study Area will be to establish a diverse vegetative cover with an interspersion of vegetative types over the reclaimed land capable of supporting livestock and wildlife. The integrity of the visual resource should be maintained.

STABILITY OF THE POSTMINING LANDSCAPE[1/]

The design of a stable postmining landscape in the Pumpkin Creek Study Area will require the integration of several critical factors. These include: (1) a detailed knowledge of the distribution of overburden materials, with emphasis on the delineation of highly sodic spoils, (2) proper equipment selection, and (3) a consideration of seasonal factors. For reclamation to be successful, consideration must be given to the entire landscape, not merely the soil zone.

1/ Groenewold, G.H. and Rehm, B.W., 1980 (modified).

Three forms of landscape instability are common on reclaimed coal-mined areas in the Northern Great Plains. These are areawide settling, local collapse, and piping.

Areawide settling is common in most postmining landscapes, but appears to cause only minimal disruption. This form of subsidence will probably be most pronounced during the first year following reclamation and will continue at a decreasing rate for a number of years. The two major factors influencing areawide settling are: (1) texture of the overburden, and (2) equipment used in spoil contouring operations.

A significant quantity of overburden in the Pumpkin Creek Study Area consists of fine-textured material (shale). When disturbed, this material usually results in more blocky and, initially, more porous spoils than does coarse-textured overburden (sandstone). Therefore, a greater degree of areawide settling may be expected in this area as compared to an area where coarse-textured materials are predominant.

Equipment used in contouring operations is a critical factor influencing areawide settling. Settlement is significantly less in scraper-contoured areas than in dozer-contoured areas due to the fact that scrapers more effectively break down large overburden blocks and compact the spoil mass. Therefore, the degree of areawide settlement may be reduced by employing scrapers rather than dozers in spoil contouring operations.

Local large-scale collapse often develops soon after contouring is completed. Development typically ends within 1 year. This form of instability is predominant in precontouring valleys where large, frozen spoil blocks are concentrated by mid-winter dozer contouring. Thawing of these blocks results in local surface subsidence. To restrict the development of local collapse features, the use of scrapers rather than dozers should be considered for contouring operations during the winter months.

Piping appears to be a severe and long-term problem in some postmining landscapes. This form of instability usually begins soon after contouring ceases and may continue for several years. In some postmining landscapes, piping has only started to develop after as much as 5 years.

Piping is apparently controlled by a combination of physical and chemical conditions in the spoils. All piping begins as a crack, either on the surface of exposed spoils or at the topsoil-spoil interface. In the latter case, the overlying topsoil collapses into the pipe and is carried away. Repeated topsoil application is usually unsuccessful in stopping the growth and development of piping. Cracking of spoils is restricted to areas of highly dispersive sodic materials. The cracks allow access for large volumes of surface runoff to flow into the subsurface of the spoils. However, surface cracking alone will not necessarily result in the development of piping. Piping will develop only if an avenue for water movement can result from fracturing within the mass of spoils due to settling between differentially compacted areas (i.e., scraper-contoured area adjacent to dozer-contoured area) or within areas of poorly compacted spoils (i.e., dozer contouring only).

Piping usually develops in nearly flat areas, where runoff is minimal and infiltration is maximized. Thus, the final surface slopes in reclaimed areas must also be recognized as controlling factors in the development of piping.

Given the proper conditions of slope, near-surface dispersive materials, and a permeable zone in the base of the spoils, piping may continue to develop and disrupt the restored landscape for many years. Selective placement of excessively sodic overburden encountered in this study area may prove to be the only effective means of controlling piping.

Because the postmining landscape in the Pumpkin Creek Study Area will be unstable, structures should not be built unless they are specifically designed to absorb differential settlement. Also, reconstructed drainage channels will require periodic maintenance to ensure that ponded areas do not develop in areas of localized settling.

GRADING AND HANDLING OF SPOIL MATERIALS

Montana law presently requires that "All final grading on the area affected shall be to the approximate original contour of the land" /Rule IV(1)(b) pursuant to the Montana Strip and Underground Mine Reclamation Act - Montana Permanent Program/. Furthermore, the mine operator will be required to "transport, backfill, compact (where advisable to ensure stability or to prevent leaching of toxic materials), and grade all spoil material to eliminate all highwalls, spoil piles, and depressions" /Rule IV(1)(d) pursuant to the Montana Strip and Underground Mine Reclamation Act - Montana Permanent Program/.

Where possible, all final grading and preparation of graded land prior to the redistribution of topsoil should be conducted along the contour to minimize erosion and maximize landscape stability.

Based on the results of laboratory analyses performed on samples from 10 drill holes in the Pumpkin Creek Study Area, it appears that a significant percentage of the bedrock strata contain excessive levels of sodium. Ideally, excessively sodic or other toxic materials should be covered with a minimum of 8 feet of nontoxic overburden. However, based on the data presented in this report, it appears as though the quantity of nontoxic overburden required to accomplish the 8-foot covering may be deficient in this study area.

EROSION CONTROL

Reducing runoff and erosion and increasing the on-site conservation of moisture for vegetative establishment are feasible objectives for reclaimed land in the Pumpkin Creek Study Area. The following procedure is recommended as a means toward achieving these objectives: (1) reduce the mean surface slope in the reclaimed area, (2) scarify the surface of the regraded spoils, (3) replace the subsoil/topsoil and prepare a seedbed, (4) conduct seeding and planting operations as soon as possible after topsoil redistribution, and (5) apply mulch to the newly seeded areas.

Reducing the mean surface slope in the reclaimed area will provide a more gently sloping landscape. A more level landscape will increase the potential for infiltration and moisture retention and decrease the potential for runoff and sediment yield. The increase in moisture retention will be highly desirable for plant reestablishment in the reclaimed area.

Prior to the redistribution of suitable plant growth material, the surface of the regraded spoils should be ripped or chiseled in order to (1) eliminate slippage surfaces at the spoil-topsoil interface, and (2) provide a favorable subsurface medium for air/water infiltration and root pentration. Ripping or chiseling should be conducted along the contour wherever possible to prevent runoff and ensure maximum stability.

Subsoil and topsoil are often compacted by heavy machinery during the redistribution process. These materials should be loosened by chiseling or other means prior to actual seedbed preparation (disking/harrowing). The loosened material will allow roots to readily penetrate its matrix and will also facilitate a higher rate of air/water infiltration. All tillage operations should be conducted along the contour to prevent excess runoff and substantial loss of the plant growth material.

Seeding and/or planting should be conducted as soon as possible after the topsoil has been spread and a seedbed has been prepared. The establishment of a permanent vegetative cover as quickly as possible will be the most effective method of controlling erosion in the reclaimed area. A temporary cover of small grains, grasses, or legumes may be required to protect the topsoil until such time as a permanent cover can be established.

Suitable mulch should be applied on all newly seeded areas to control erosion, conserve soil moisture, and enhance seed germination. The application of hay or straw mulch at a rate of about 2 tons/acre should be considered for the Pumpkin Creek Study Area. To prevent substantial losses of the mulching material due to blowing, the hay or straw should be anchored (disked or crimped) to the soil surface.

REVEGETATION

Revegetation of surface-mined land in the Pumpkin Creek Study Area will require: (1) removal, segregation, and redistribution of suitable plant growth material, (2) selection of adapted plant species, and (3) use of proper seedbed preparation and planting procedures.

Removal, Segregation, and Redistribution of Suitable Plant Growth Material

Montana regulations require that "All available topsoil shall be removed from the area of land affected before further disturbance occurs. The operator shall segregate surface soil material (A and possibly portions of underlying B and C horizons) from subsurface material (B and C horizons) in the salvage, stockpiling, and redistribution of topsoil" /Rule VIII(1) pursuant to the Montana Strip and Underground Mine Reclamation Act - Montana Permanent Program/. The segregation of surface soil material and subsurface soil material is accomplished in a 2-lift process, with the most desirable

plant growth material (topsoil) being removed in the first lift and the remaining suitable material (subsoil) being salvaged in the second lift. Based on the results of the Land Suitability Survey included in this report, it appears that a minimum of 6 inches of fair to good quality surface material (topsoil) could be removed in the first lift from most soils in this study area. This material is typically nonsaline, non-sodic, and moderately permeable. The quantity and quality of subsurface material (subsoil) in this study area is highly variable.

Ideally, topsoil/subsoil redistribution should proceed concurrently with mining operation. However, if stockpiling of the suitable plant growth material is necessary, the stockpiles should be selectively placed on a stable area and protected from erosion, compaction and contaminants (toxic spoils). Establishment of a quick growing vegetative cover on the stockpiles is probably the most effective method of protection; however, other measures such as snow fences, mulches, or chemical binders may also be considered.

Before the suitable plant growth material is redistributed, the regraded land should be scarified (ripped) to eliminate slippage surfaces and enhance root penetration. The redistribution of subsoil and topsoil, respectively, should proceed in a manner that achieves an approximate uniform thickness consistent with the post mining land use(s) and prevents excess compaction of the spoils and suitable plant growth material.

Finally, nutrients (fertilizer) and/or soil amendments should be added to the surface soil layer in the amounts determined by soil tests. All soil analyses should be performed by a qualified laboratory using procedures approved by the Montana Department of State Lands.

Selection of Adapted Plants

To comply with present State regulations, "A diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected . . . shall be established on all areas of land affected except water areas and the surface area of roads that are approved as a part of the postmining land use" /Rule IX(1) pursuant to the Montana Strip and Underground Mine Reclamation Act - Montana Permanent Program/. Introduced species may be approved for use by the Department of State Lands if appropriate field trials demonstrate that the introduced species are of equal or superior utility for the approved postmining land use or are necessary to achieve a quick, temporary, and stabilizing cover.

Some important considerations in selecting plant species for revegetation in the Pumpkin Creek Study Area should include: drought resistance, salt and sodium tolerance, resistance to winterkill, palatability, and resistance to grazing pressure. Of equal importance is plant compatability with soil type, slope, aspect, and drainage conditions. Table 1 is an example listing of adapted plant species and seeding rates which could be considered for use in the Pumpkin Creek Study Area.

RANGELAND SEED MIXTURE[2/]

		Lbs./Acre
Western Wheatgrass	Agropyron smithii	4.0
Thickspike Wheatgrass	Agropyron dasystachyum	2.0
Slender Wheatgrass	Agropyron trachycaulum	3.0
Whitmer Beardless Wheatgrass	Agropyron inerme	3.0
Pubescent Wheatgrass	Agropyron trichophorum	1.0
Alkali Sacaton	Sporobolus airvides	1.0
Green Needlegrass	Stipa viridula	3.0
Sainfoin	Onobrychis viciaefolia	3.0
Sideoats Grama	Bouteloua curtipendula	2.0
Indian Ricegrass	Oryzopsis hymenoides	1.0
Four-wing Saltbush	Atriplex canescens	1.0
*Purple Prairie Clover	Petalostemon purpureum	0.25
*Big Sagebrush	Artemisia tridentata	0.125
*Blue Flax	Linum perenne	0.25
*Western Yarrow	Achillea millefolium	0.25
	Total	24.875[3/]

*All seed, except for these, are pure live seed.

DRAINAGE/LOWLAND SEED MIXTURE[2/]

		Lbs./Acre
Green Needlegrass	Stipa viridula	2.0
Western Wheatgrass	Agropyron smithii	4.0
Thickspike Wheatgrass	Agropyron dasystachyum	4.0
Pubescent Wheatgrass	Agropyron trichophorum	2.0
Regar Brome	Bromus bierbersteinii	1.0
Canada Wild Rye	Elymus canadensis	1.0
Cicer Milkvetch	Astragalus cicer	1.0
Eski Sanfoin	Onobrychis viciaefolia	3.0
*Western Yarrow	Achillea millefolium	0.25
*Silver Sagebrush	Artemisia cana	0.125
*Wild Rose	Rosa spp.	0.25
*Western Snowberry	Symphericarpus occidentalis	0.25
	Total	18.875[3/]

*All seed, except for these, are pure live seed.

2/ From: Draft Environmental Statement - West Decker Mine, Bighorn County, Montana, Montana Department of State Lands, 1980.

3/ Rates listed are for drill seeding. For broadcast seeding, rates should be doubled.

TREE/SHRUB INCLUSIONS FOR DRAINAGES/LOWLANDS

Ponderosa Pine	*Pinus ponderosa*
Common Chokecherry	*Prunus virginiana*
Skunkbush Sumac	*Rhus trilobata*
Cottonwood	*Populus spp.*
Willow	*Salix spp.*
Russian Olive	*Elaegnus augustifolia*
Siberian Peashrub	*Caragana arborescens*
Golden Current	*Ribes aureum*
Western Snowberry	*Symphoricarpos occidentalis*
Silver Buffaloberry	*Shepherdia argentea*

The establishment of a diverse vegetative cover with an interspersion of vegetative types over the reclaimed land will aid in restoring wildlife habitat in the area.

Seedbed Preparation and Planting

To provide a plant medium favorable for air and water infiltration, as well as root penetration, the topsoil/subsoil should be chiseled to a depth of 18 to 24 inches prior to seedbed preparation. Disking/harrowing should then be conducted until a suitable seedbed is achieved.

Seeding of grasses and legumes with a press drill is usually the preferred technique; however, broadcasting is also widely accepted. Drilling is considered superior because the seed is covered to a proper depth, rate of seeding is controlled, seed distribution is uniform, and soil compaction can be accomplished with packer wheels attached to the drill. Broadcasting is considered less efficient because the seeds often perch on top of the soil, where germination and establishment are difficult. Seed that is broadcast should always receive some form of mechanical treatment to give it suitable coverage, unless the bed is loose so that natural sloughing of soil will cover the seed.[4/]

Natural woodland complexes (woody draws) occur to a minor extent in this study area. These complexes should be avoided during the mining operation, if at all possible, as they are irreplaceable ecosystems which provide nesting cover and feed for game and non-game animals. If disturbance of these complexes cannot be avoided, the trees and shrubs should be salvaged for transplanting in reconstructed drainages.

Seeding and planting operations should be conducted during the first normal period for favorable planting conditions following the redistribution of suitable plant growth material. In the Pumpkin Creek Study Area, either early spring or late fall planting of grasses and legumes appears most desirable. If spring planting is selected, the plants should be seeded between early March and late April in order that seedlings may emerge before the spring rains begin. If late fall planting is chosen, seeding should be conducted after mid-October to prevent germination.

POST-RECLAMATION MANAGEMENT

Responsibility of the Mine Operator

The period of responsibility under the performance bond will begin when the canopy cover of seeded species is comparable to the approved standard[5/] after the last year of seeding, fertilizing, irrigating, or other work. "Comparable to the approved standard" is defined as not significantly less

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4/ USDA, Forest Service, General Technical Report, INT-64, 1979.

5/ Approved standard refers to an undisturbed "reference area" chosen for comparative purposes to determine success of revegetation on the reclaimed site.

than the approved standard with 90 percent statistical confidence for herbaceous vegetation or 80 percent statistical confidence for trees, shrubs, or half-shrubs. In no case will an area be considered comparable if it is less than 90 percent of the approved standard /Rule IX(15)(b)(i) - Montana Permanent Program/.

The revegetated areas and their respective reference areas will be evaluated for at least two consecutive years prior to application for bond release and shall include the last two consecutive years of the bonding period. Application for bond release may not be submitted prior to the end of the tenth growing season /Rule IX(15)(b)(ii) - Montana Permanent Program/.

On lands restored to rangeland, the reference areas and revegetated areas will both be grazed at a proper level (50 percent or less utilization) for at least the last two years of the bonding period. Vegetation measurements these last two years will be on areas exclosed from grazing by agronomy cages or other systems approved by the Department of State Lands /Rule IX(15)(a)(iv) - Montana Permanent Program/.

Responsibility of the Landowner

The landowners in the Pumpkin Creek Study Area will resume responsibility for management of the reclaimed lands following termination of the mine operator's responsibility period. To ensure that the reclaimed land remains stable and productive, the landowners should implement proper range and soil/crop management practices.

On areas restored to rangeland, grazing should be limited to a capacity that the reclaimed land is capable of supporting. Overgrazing reclaimed lands will result in a reduced vegetative cover, accelerated erosion, and an overall decrease in productivity.

On areas returned to cropland, the main objective of the landowner in cultivating the land should be sustained profitable production. To aid in achieving this objective, soil/crop management practices including contour-tillage, fertilization, crop rotation, weed and insect control, mulching, etc., should be utilized whenever possible.

HYDROLOGY RECOMMENDATIONS

The proposed surface mining of the Sawyer-"A" Coalbed in the Pumpkin Creek Study Area will result in some alteration of the ground water, surface water, and geochemical regimes. The following recommendations are designed to mitigate or minimize any deleterious effects.

1. Water wells removed by mining could be replaced by wells of similar or better yield and quality tapping undisturbed aquifers below the Lebo Shale Member of the Fort Union Formation. Springs destroyed during mining could be replaced by wells drilled to deep aquifers below the Lebo Shale Member.

2. Ground water contamination from pollutants or contaminants produced during mining operations could be minimized by not allowing the pollutants to percolate below the mine floor.

3. Toxic materials produced through mining or unearthed by mining could be removed from the mine site or could be isolated between impermeable layers well above the premining water table and away from water courses to minimize the effects of mine spoils on postmining ground water quality.

4. Surface water could be diverted around mine cuts to minimize erosion and/or sediment transport leaving the disturbed areas.

5. Premining reservoirs or natural depressions removed with stripmine overburden could be replaced on spoils to distribute and retard overland flow across potentially erodible materials. Special care to reservoir design could minimize potential leakage through bottom liners to ground water to minimize leaching of soluble salts into underlying ground water bodies.

6. The spoil surface could be shaped, contoured, and prepared to maintain premining quantities of catchment and infiltration characteristics.

7. Surface conditioning of soil could enhance infiltration and maximize utilization of normal precipitation.

Future Hydrologic Monitoring

Continued streamflow, ground water level, and water quality monitoring is necessary to resolve seasonal fluctuations and to define the hydrologic system more completely in the study area. Results from the existing monitoring program will constantly be analyzed to determine the need for continued data collection.

Detailed description of water problems that may occur from specific surface mining cuts within the East Pumpkin Creek Coalfield is beyond the scope of this project. An intensive monitoring program would be needed to provide an accurate accounting of the impacts of each mine plan. Such a program would include monitoring water quantity and quality of livestock reservoirs, ephemeral streams, and ground water downgradient from the mine plan from the time of mine planning through reclamation.

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PUMPKIN CREEK STUDY AREA

R 48 E R 49 E R 50 E R 51 E R 52 E

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SCALE OF MILES

ALWAYS THINK SAFETY

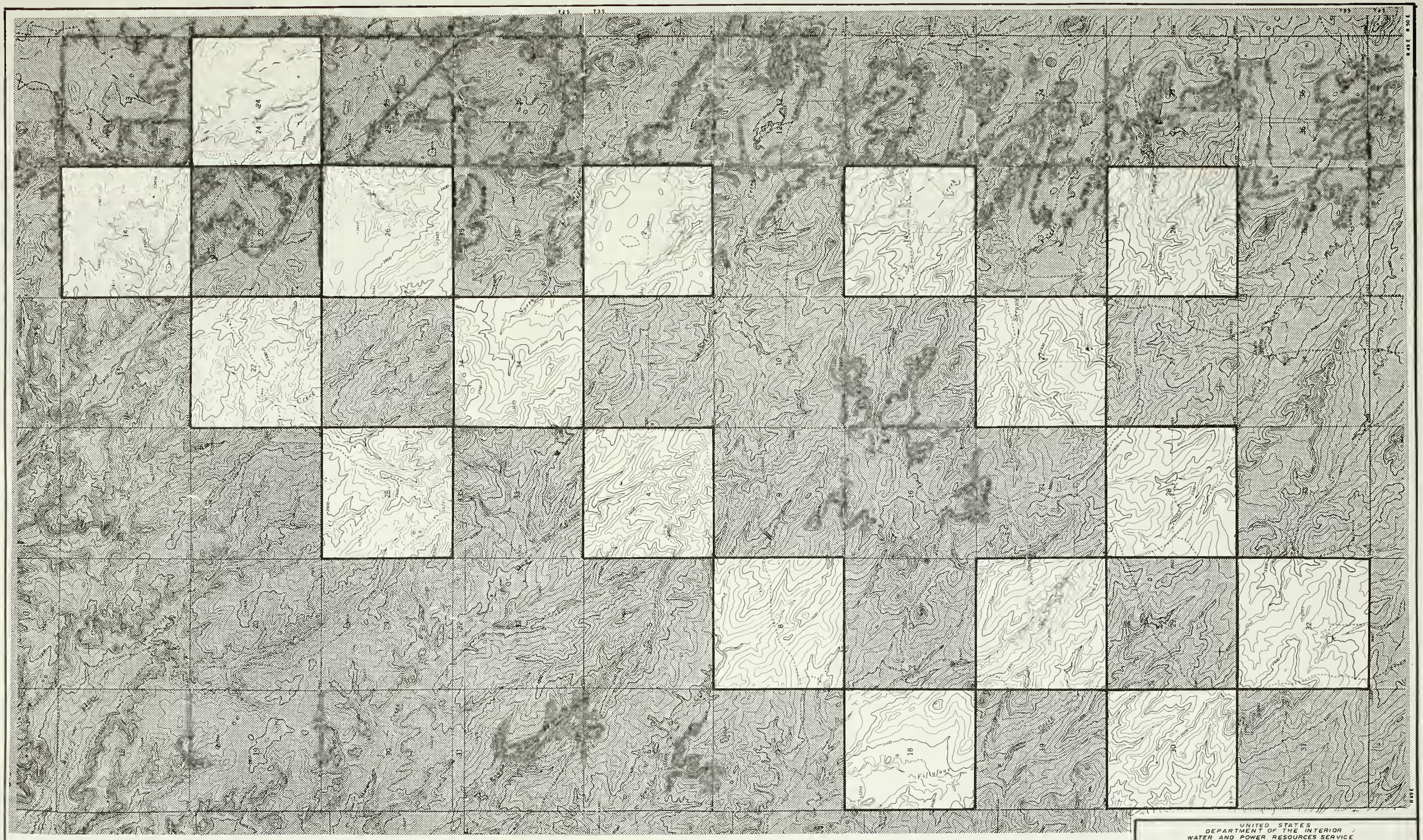
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE AND POTENTIAL RECLAMATION EVALUATION
PUMPKIN CREEK STUDY AREA
PUMPKIN CREEK COALFIELD - MONTANA

GENERAL LOCATION MAP

DESIGNED _____ SUBMITTED _____
DRAWN L E ALLSOP RECOMMENDED _____
CHECKED _____ APPROVED _____

BILLINGS, MONTANA OCTOBER, 1981 1305-600-206

Plate 2



CONTOUR INTERVAL 20 FEET

NOTE

Study area not shaded

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

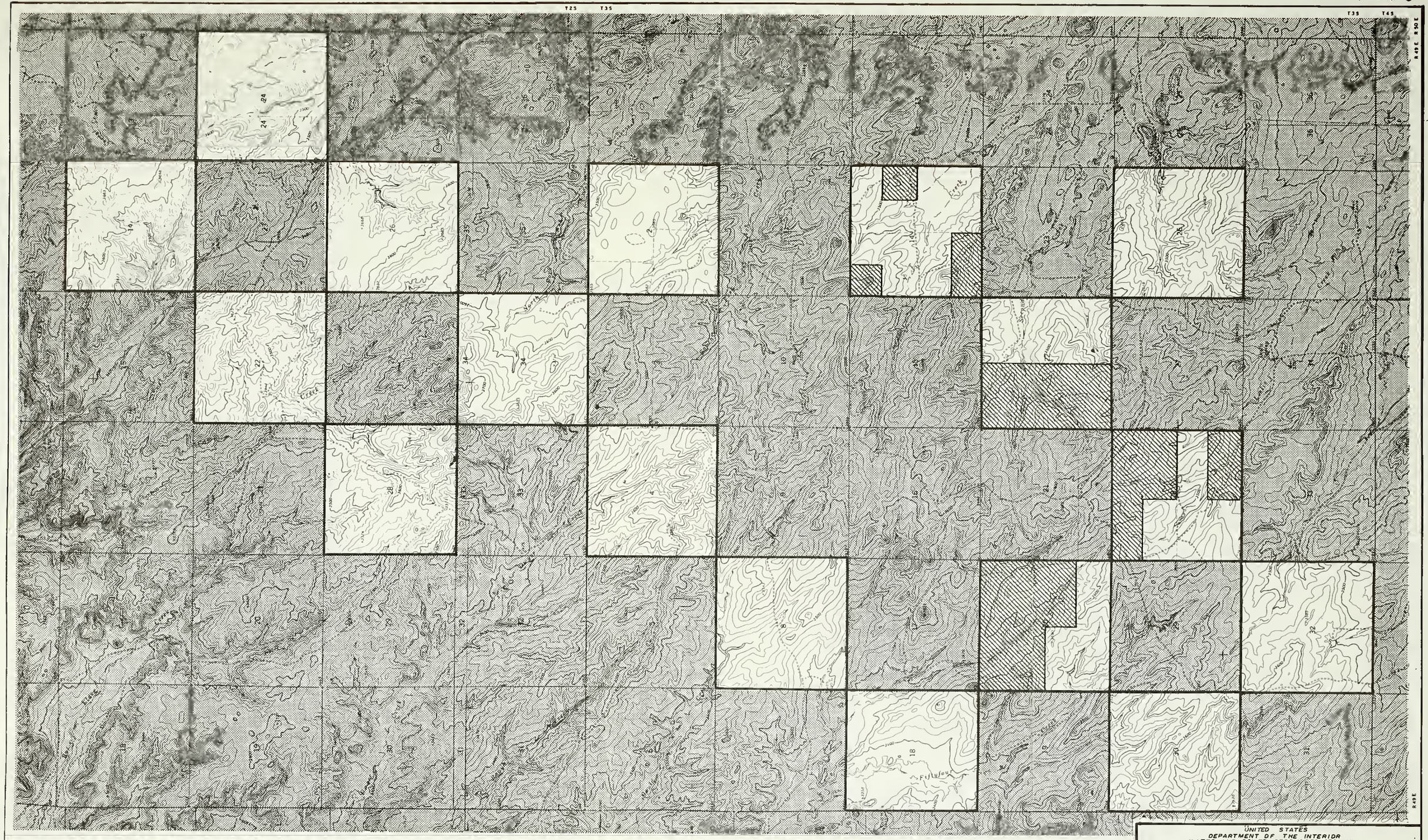
RESOURC AND POTENTIAL RECLAMATION EVALUATION

PUMPKIN CREEK STUDY AREA
PUMPKIN CREEK COALFIELD

DESIGNED G. WESTMAN	FIELD APPROVAL
DRAWN L.E. ALLSOP	TECHNICAL APPROVAL
CHECKED	APPROVED
BILLINGS, MONTANA	MARCH 1981

1305-600-207

Plate 3



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CONTOUR INTERVAL 20 FEET

LAND OWNED BY THE
FEDERAL GOVERNMENT

NOTE
Study area not shaded

UNITED STATES
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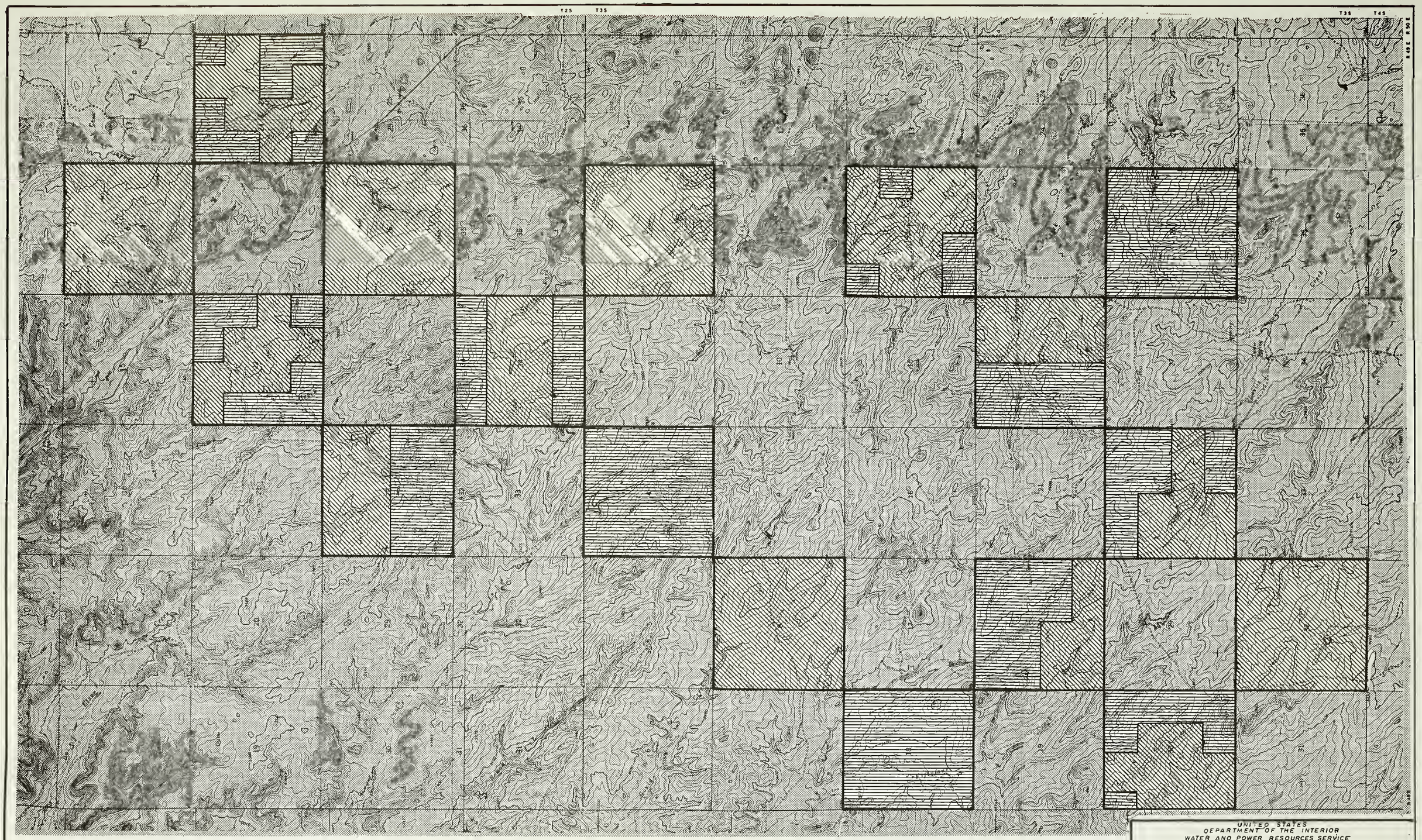
WATER AND POWER RESOURCES SERVICE

RESOURCE AND POTENTIAL RECLAMATION EVALUATION

PUMPKIN CREEK STUDY AREA
PUMPKIN CREEK COALFIELD
LAND STATUS MAP

DESIGNED G WESTMAN FIELD APPROVAL
DRAWN L E ALLSOP TECHNICAL APPROVAL
CHECKED APPROVED

BILLINGS, MONTANA MARCH, 1981 1305-600-208



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CONTOUR INTERVAL 20 FEET

NOTE
Study area not shaded

MINERALS OWNED BY
THE FEDERAL GOVERNMENT

SYMBOLS	MINERAL RIGHTS
	All minerals
	Coal only

UNITED STATES
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RESOURCE AND POTENTIAL RECLAMATION EVALUATION

PUMPKIN CREEK STUDY AREA
PUMPKIN CREEK COALFIELD
MINERAL STATUS MAP

DESIGNED G. WESTMAN	FIELD APPROVAL
DRAWN L. E. ALLSOP	TECNICAL APPROVAL
CHECKED	APPROVED
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